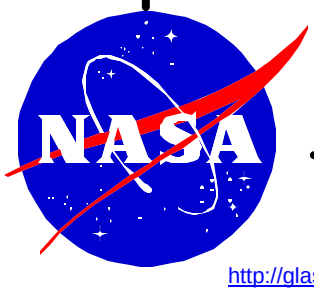
GAMMA-RAY LARGE AREA SPACE TELESCOPE (GLAST) PROJECT

GROUND SYSTEM REQUIREMENTS DOCUMENT

JULY 3, 2003



GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

GAMMA-RAY LARGE AREA SPACE TELESCOPE
(GLAST)
PROJECT

GROUND SYSTEM REQUIREMENTS DOCUMENT

JULY 3, 2003

NASA Goddard Space Flight Center

Greenbelt, Maryland

GLAST PROJECT GROUND SYSTEM REQUIREMENTS DOCUMENT

Prepared by:

Original Signed **07/09/03**

Bruce Wagner
GLAST Ground System Engineer

Date

Concurrence:

Original Signed **07/09/03**

Dennis Small
GLAST MOC Implementation Lead

Date

(Additional leads will be added in later revisions)

Approved by:

Original Signed **07/09/03**

Michael Rackley
GLAST Ground System/Ops Manager

Date

Original Signed **07/14/03**

Jack Leibee
GLAST Systems Manager

Date

Original Signed **07/15/03**

Al Vernacchio
GLAST Deputy Project Manager

Date

Original Signed **07/17/03**

Kevin Grady
GLAST Project Manager

Date

CHANGE RECORD PAGE

DOCUMENT TITLE: GLAST Project Ground System Requirements Document

DOCUMENT DATE: July 3, 2003

ISSUE	DATE	PAGES AFFECTED	DESCRIPTION
Original	07/03/03	All	Baseline. CCR 433-0149 R1

TABLE OF CONTENTS

Acronyms

APIDs	Application Identifications
ASI	Italian Space Agency
ATS	Absolute Time Sequence
BAPs	Burst Alert Processors
CCSDS	Consultative Committee for Space Data Systems
DAS	Demand Access System
EU	Engineering Unit
FOT	Flight Operations Team
FSW	Flight Software
GBM	GLAST Burst Monitor
GCN	Gamma ray Coordinates Network
GIOC	GBM Instrument Operations Center
GLAST	Gamma ray Large Area Space Telescope
GN	Ground Network
GPS	Global Positioning System
HEASARC	High Energy Astrophysics Science Archive Research Center
HK	Housekeeping
ICD	Interface Control Document
IOC	Instrument Operations Center
IT	Information Technology
Kbps	kilobits per second
KSC	Kennedy Space Center
LAT	Large Area Telescope
L&EO	Launch and Early Orbit
LIOC	LAT Instrument Operation Center
MOC	Mission Operations Center
NASA	National Aeronautics and Space Administration
PDB	Project Database
RT	Real Time
RTS	Relative Time Sequence
S/C	Spacecraft
SN	Space Network
SSC	Science Support Center
SSR	Solid State Recorder
SWSI	Space Network Web-based Scheduling Interface
T&C	Telemetry and Command
TDRSS	Tracking and Data Relay Satellite System
ToO	Target of Opportunity
TLE	Two Line Elements
UPS	Uninterruptible Power Supply
VC	Virtual Channel

1 Introduction

1.1 Purpose and Scope

This Gamma-ray Large Area Space Telescope (GLAST) Ground System Requirements Document specifies the Level 3 requirements of the GLAST Project for processing, analyzing, and archiving the data acquired by the Observatory for all phases of the mission. Requirements are specified for facilities, analysis software development, documentation, support services and data delivery and archiving. The interfaces between the GLAST-wide data analysis system and the particle and astrophysics communities are also specified for the science team to access the science data in timely manner.

Note: This initial baseline only applies only to the Mission Operations Center (MOC) to facilitate establishment of the MOC contract. Later revisions will incorporate requirements for the other ground system elements.

1.2 Document Organization

The document organization has the system requirements defined followed by the requirements for each of the elements ground communication, ground station, space network, Mission Operations Center, FDF, LAT IOC, GBM IOC, SSC, GCN, HEASARC, spacecraft I&T facility, and KSC. The requirement tables in the following section contain a column for a unique requirement identification number, description, comment, source, and source identification number.

1.3 Requirements Trace Methodology

The purpose of tracing system requirements is to ensure that a requirement is based on an approved parent requirement or set of requirements. The requirements specified in this document are primarily derived from GLAST Project Mission System Specification and the GLAST Operations Concept Document.

1.4 System Architecture

The GLAST is National Aeronautics and Space Administration's (NASA) next major mission dedicated to observations of high energy gamma rays. The two instruments used to accomplish its scientific goals are the Large Area Telescope (LAT) and the GLAST Burst Monitor (GBM). Spectrum Astro of Gilbert, AZ is responsible for the design and manufacture of the GLAST spacecraft (S/C), integration of the two scientific instruments with the S/C, and integration of the complete space vehicle/observatory with the Delta launch vehicle. Spectrum Astro may also be retained for the duration of the GLAST mission to provide sustaining engineering support to the Flight Operations Team (FOT) and to maintain the flight software for the spacecraft. The GLAST observatory is

scheduled for launch on a Boeing Delta II 2920H-10 vehicle from the Kennedy Space Flight Center's (KSC) Eastern Test Range, Florida in September 2006.

The LAT Instrument Operation Center (LIOC) is located at the Stanford Linear Accelerator Center (SLAC) at Stanford University, CA. The LIOC will direct the instrument operations and data processing for the LAT. The GBM Instrument Operations Center (GIOC) is located at Marshall Space Flight Center and will direct the GBM instrument operations and data processing. The GLAST Science Support Center (SSC) runs the guest investigator program, creates and maintains the mission time line from the guest investigator program (after the first year), creates the scientific goals of the mission, provides analysis tools for the scientific community, and archives the GLAST data. The SSC is located at GSFC and collects inputs from the two Instrument Operations Centers (IOCs) for the creation of the instrument timeline which is then sent to the MOC. The SSC provides data to the general user community and will also interface with the High Energy Astrophysics Science Archive Research Center (HEASARC). The HEASARC is an archive of astronomy data collected from several extreme ultraviolet, X-ray, and gamma-ray observatories.

The MOC, located at GSFC, is the central point of the ground system architecture. GLAST operations include not only the operation of the S/C and instruments, but also the operation of the ground system itself. The MOC will have interfaces with all areas of the GLAST system shown in Figure 1-1. The MOC will generate the integrated observatory timeline, monitor the health and safety of the observatory, schedule ground station and Tracking and Data Relay Satellite System (TDRSS) contacts, perform level zero processing, and support special engineering activities. GLAST will utilize the Global Positioning System (GPS) of satellites for onboard orbit determination and clock management. The MOC procedures and software allow automation of telemetry monitoring to not only support off-shift periods, but to optimize MOC staffing during the regular 5-day shifts. GLAST will be supported by five to seven ground contacts per day.

The Italian Space Agency (ASI) is contributing the Malindi ground station in Kenya for S/C telemetry downlink and command uplink. Universal Space Network of Horsham, PA is contributing support of the South Point, Hawaii ground station for S/C telemetry downlink and command uplink. These ground stations are capable of uplinking commands received from the MOC and collecting both S-band and X-band data downlinked by GLAST. GLAST will also utilize the near continuous coverage provided by the TDRSS space network (SN) for telemetry and commanding as well as special instrument events known as bursts alerts. Burst Alerts are messages generated in response to major gamma ray events and are immediately downlinked to the MOC using TDRSS. These events are then forwarded directly to the Gamma Ray Coordinates Network (GCN) for further distribution to the science community.

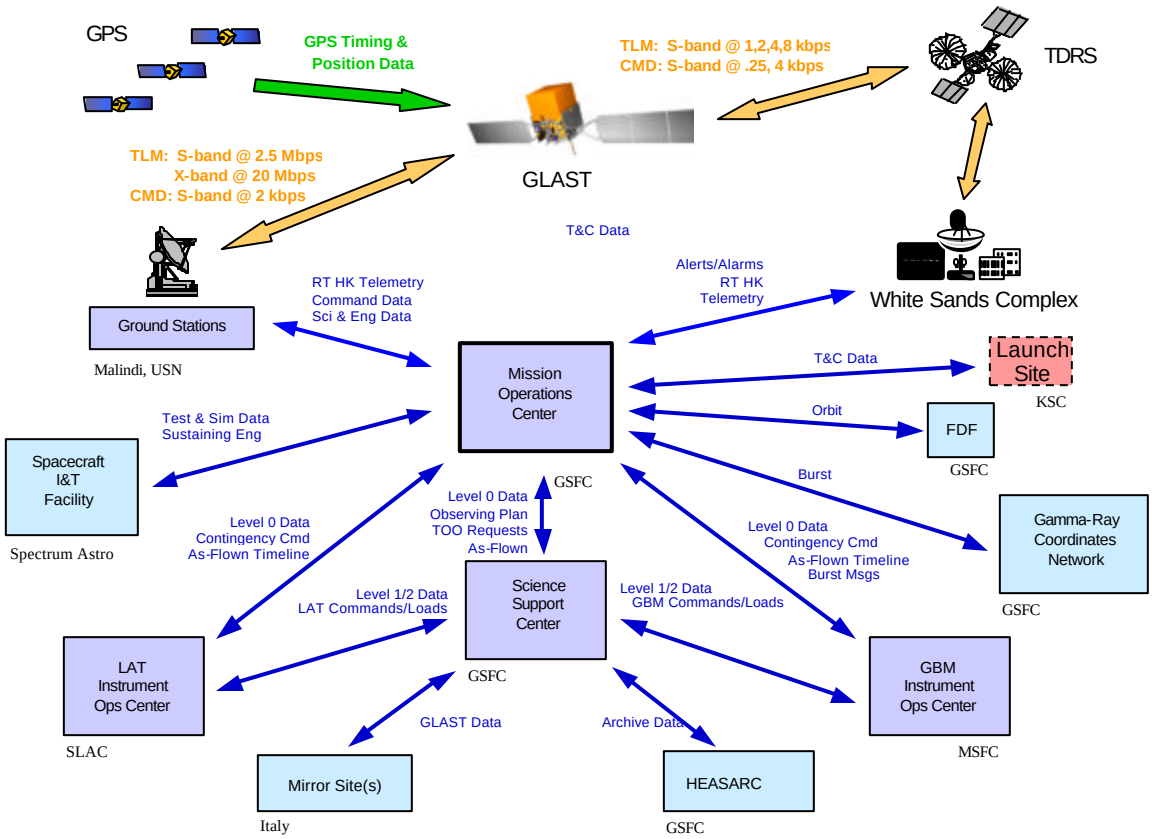


Figure 1-1 GLAST Ground System and Data Interface Diagram

1.5 Definitions

The following definitions provide the meanings for the terms as they are used in this document.

Observatory – The GLAST S/C including the LAT and GBM instruments.

Project Database (PDB) – The database the FOT will maintain for the ITOS ground system that will be derived from the observatory Telemetry and Command (T&C) database delivered by the spacecraft vendor and other ancillary data required for flight operations.

PDB Verification – Includes syntax level checking of the database content and format.

PDB Validation – Process of validating that the execution of the PDB commands leads to the expected results.

Telemetry decommutation – To extract from the telemetry stream the housekeeping (h/k) parameters which then are subjected to the appropriate database conversion.

2 Applicable and Reference Documents

2.1 Applicable Documents

The following documents contain requirements that are invoked by this Ground System Requirements Document:

433-SRD-0001, GLAST Science Requirements Document

433-SPEC-0001, GLAST Project Mission System Specification

433-MAR-0004, GLAST Ground Data System Mission Assurance Requirements

CCSDS 101.0-B-5: "Recommendation for Space Data Systems Standards. Telemetry Channel Coding." Blue Book. Issue 5. June 2001

CCSDS 102.0-B-5: "Recommendation for Space Data Systems Standards Packet Telemetry." Blue Book. Issue 5. November 2000.

CCSDS 103.0-B-2: "Recommendation for Space Data Systems Standards Packet Telemetry Service Specification." Blue Book. Issue 2. June 2001.

CCSDS 201.0-B-3: "Recommendation for Space Data Systems Standards Telecommand Part 1 -- Channel Service." Blue Book. Issue 3. June 2000.

CCSDS 202.0-B-3: "Recommendation for Space Data Systems Standards Telecommand Part 2 -- Data Routing Service." Blue Book. Issue 3. June 2001.

CCSDS 202.1-B-2: "Recommendation for Space Data Systems Standards Telecommand Part 2.1 -- Command Operation Procedures." Blue Book. Issue 2. June 2001.

CCSDS 203.0-B-2: "Recommendation for Space Data Systems Standards Telecommand Part 3 -- Data Management Service." Blue Book. Issue 2. June 2001.

CCDS 701.0-B-3: "Recommendation for Space Data Systems Standards Advanced Orbiting Systems, Networks and Data Links: Architectural Specification." Blue Book. Issue 3. June 2001.

NPD 8010.2C, NASA Policy Directive, Use of the Metric System of Measurement in NASA Programs, July 2000.

NPD 2810.1, NASA Policy Directive, Security of Information Technology, October 1998.

NPD 2820.1, NASA Policy Directive, NASA Software Policies, May 1998.

Recommendation ITU-R SA.1157: Protection Criteria for Deep-Space Research (1995).

2.2 Reference Documents

The following document is for reference only.

433-OPS-0001, GLAST Operations Concept Document.

3 Requirements

3.1 System Requirements

Req ID	Requirement	Comments	Source	Source ID
General				
SYS0010	The ground system shall observe the current NASA policy directive, NPD 8010.2C, Use of the Metric System of Measurement in NASA programs.		MSS	3.5.1.12
SYS0020	The ground system shall accommodate observatory telemetry that is compliant with the CCSDS Packet Telemetry Recommendations as defined in the Series 100 Blue Books.		MSS	3.1.2.5.1.1 3.5.2.4.1 3.1.4.3.1.2
SYS0030	The ground system shall accommodate observatory commanding that is compliant with the CCSDS Telecommand recommendations as defined in the Series 200 Blue Books.		MSS	3.1.4.3.1.2
SYS0040	The ground system shall use Universal Time Coordinated (UTC) as the time base.			Derived
SYS0050	The ground system shall provide the capability to plan and schedule science observations for the observatory		MSS	3.5.2.3
SYS0060	The ground system shall provide the capability to generate and send commands to the observatory		MSS	3.5.2.2 3.5.2.3
SYS0070	The ground system shall provide the capability to process and archive all telemetry received from the observatory		MSS	3.5.2.2 3.5.2.3 3.5.2.4

Req ID	Requirement	Comments	Source	Source ID
SYS0080	The ground system shall provide RF communications capability for the transmission of commands and telemetry to/from the observatory via the Ground Network (GN) and the Space Network (SN)		MSS	3.1.1.5.1
SYS0090	The ground system shall provide the ground communications network capability for the exchange of mission data among the ground system elements		MSS	3.5.1.11
SYS0100	The ground system shall provide the capability to perform health and safety monitoring of the observatory		MSS	3.5.2.2
SYS0110	The ground system shall provide the capability to process and archive all science data received from the observatory		MSS	3.5.2.4
SYS0120	The ground system shall provide the capability to support sustaining engineering of the observatory	Including FSW maintenance, loads, special commanding, data analysis and trending	MSS	3.5.2.2
SYS0130	The ground system shall provide the capability to relay GRB alerts to the science community via the Gamma-ray Coordinates Network (GCN) within 6 seconds for at least 80% of all burst alerts.	This is the current allocation to the ground system from the end-to-end 7 second requirement stated in the MSS.	MSS	3.5.2.8 3.1.4.1.2 3.1.4.1.3
SYS0140	The ground system shall be able to support a single higher level science analysis software environment for use by the science community and instrument teams.	This is applicable to the SSC and IOCs.	MSS	3.5.1.4

Req ID	Requirement	Comments	Source	Source ID
SYS0150	The ground system science analysis shall respect standards that ensure software portability, independence if vendor and compatibility with existing multi-mission high energy astrophysics tools.	This is applicable to the SSC and IOCs. This requirement ensures that the software tools are usable and accessible by a large community that may not specialize in GLAST analysis.	MSS	3.5.1.5
SYS0160	The ground system shall have the ability to execute a ToO order within 6 hours of approval of a ToO request from the Project Scientist.	This includes the time starting from the Project Scientist approving the request to ending when the commands hit the spacecraft.	MSS	3.5.2.7.2
SYS0170	The ground system shall have the ability to support the in-orbit checkout period.	The in-orbit checkout period is expected to be 60 days.	MSS	3.5.1.7
SYS0180	The ground system shall meet all requirements with the observatory at any orbit altitude between 575km and 450 km.		MSS	3.5.1.9.4
SYS0190	The ground system shall use the J2000 inertial coordinate system.		MSS	3.5.1.10.1
SYS0200	The ground system shall use RA and DEC a standard means of receiving and communicating pointing directions.		MSS	3.5.1.10.2
SYS0210	The ground system shall reorient the observatory as needed to within the pointing envelope of the sky survey mode for downlink transmissions of science data.		MSS	3.5.2.1.1
SYS0220	The ground system shall use the observatory in pointed observation mode to acquire observation data on known celestial sources		MSS	3.5.2.1.2

Req ID	Requirement	Comments	Source	Source ID
SYS0230	The ground system shall maintain SAA boundary definitions relative to the spacecraft during the course of the mission.	The spacecraft will automatically detect SAA entry and exit and will notify the instruments accordingly. The MOC will maintain the on-board SAA map used by the spacecraft.	MSS	3.5.2.2.3
SYS0240	The ground system shall be capable of downlinking up to 36 hours of recorded science and housekeeping data.		MSS	3.5.2.4.2
SYS0250	The ground systems contribution to Spacecraft Data Loss shall be less than 1.9%.		MSS	3.5.2.4.4
Reliability & Availability				
SYS1000	The ground system shall support observatory operations 24hours/day 365+ days/year.	Availability shall be supported by autonomous operation or personnel where applicable.		Derived
SYS1010	The ground system shall use land line communication links that provide error-free data transmission and delivery.		MSS	3.5.1.11
SYS1020	The ground system shall have the ability to support at minimum 95% (TBD) of the ToO requests.			Derived
SYS1030	The ground systems contribution to Spacecraft Data Loss shall be less than 1.9%.	The ground system allocation begins once the data leaves the spacecraft.	MSS	3.5.2.4.4
SYS1040	The ground system shall provide a reliability of .9998 for mission critical functions.		MSS	3.5.1.4
Data Processing				
SYS2000	The ground system shall be capable of processing the observatory data into science data products within 72 hours at minimum 95% of the time.	The time starts when the data is stored in the on-board SSR and ends once the Level 2 data products have been generated. This is the ground system allocation from the overall 72 hour data latency.	MSS	3.5.2.4.2

Req ID	Requirement	Comments	Source	Source ID
SYS2010	The ground system shall be capable of processing the observatory data into science data products within 36 hours at minimum 95% of the time.	The time starts when the data is stored in the on-board SSR and ends once the Level 2 data products have been generated. This is the ground system allocation from the overall 72 hour data latency.	MSS	3.5.2.4.2
Real-time Operations				
SYS4000	The ground system shall ensure that the MOC is the sole interface between the ground system elements and the space-ground communications links.		MSS	3.5.3.1.1
Security				
SYS0500	The ground system shall comply with Information Technology (IT) security requirements specified in NPG 2810.1.		MSS	3.5.1.2
Integration & Test				
SYS3000	The ground system shall provide the unique capabilities to support pre-launch testing.	Example is providing a link between the MOC and Spacecraft I&T Facility to support interface and operations testing.	MSS	3.5.1.6 derived
Anomaly Response				

Req ID	Requirement	Comments	Source	Source ID
SYS9000	The ground system shall ensure that no single point of failure exists for launch critical functions.	Ground System launch critical functions are the ability to: - Acquire, receive, process, archive, and display HK telemetry data. - Operate and manage the observatory. - Perform observatory engineering analysis. - Generate and uplink real-time commands, stored command loads, and memory loads. - Dump and perform Level 0 processing on observatory HK and science data. This does NOT include: - Processing and handling of Burst Alerts and ToOs. - Science observation planning. - Level 1 and above science data processing. - Any processing related to GBM.	MSS	3.3.1.5 derived from observatory requirement

3.2 Ground Communication Requirements

This section will be provided in a later revision to this document.

3.3 Ground Station Requirements

This section will be provided in a later revision to this document.

3.4 Space Network Requirements

This section will be provided in a later revision to this document.

3.5 Mission Operations Center Requirements

Req ID	Requirement	Comments	Source	Source ID
System				
MOC1000	The MOC shall perform mission planning & scheduling, command generation, real-time (R/T) command and telemetry processing, mission monitoring and analysis, data processing, and automated pass execution functions for command & control and health & safety monitoring of the GLAST S/Cfor the life of the mission.		MSS	3.5.1.8
MOC1010	The MOC shall be the sole interface for commands between the elements of the ground system and the space-ground communications links.		MSS	3.5.3.1.1
MOC1020	The MOC shall restrict computer access to authorized personnel		MSS	3.5.1.2 derived
MOC1030	The MOC shall have the capability to support mission operations 24-hours per day, 7 days per week		MSS	3.5.1.8 derived
MOC1040	The MOC shall provide the capability to support a single 8-hour by 5-day shift (M-F) approach and shall operate autonomously whenever not staffed.		MSS	3.5.1.3 & 3.5.1.8 derived
MOC1050	The MOC shall automatically detect ground system and S/C anomalies and page on-call personnel when appropriate.		MSS	3.5.1.3 derived
MOC1060	The MOC shall provide the capability to support automated ground station pass execution.		MSS	3.5.1.3 derived

Req ID	Requirement	Comments	Source	Source ID
MOC1070	The MOC shall be capable of operating autonomously for at least 96 hours without operator intervention or fail-over.		MSS	3.5.2.2 derived
MOC1080	The MOC shall provide the capability for authorized remote users to access system functions for viewing RT and historical data.		MSS	3.5.1.2 3.5.3.5 derived
MOC1090	The MOC shall provide the capability to fail-over to a backup system within 1 minute for launch critical functions.		MSS	3.5.2.4.4 derived
MOC1100	The MOC shall provide backup capabilities for all systems and functions.		MSS	3.1.4.2.1.3 & 3.5.2.4.4
MOC1110	The MOC shall provide the capability to fail-over to a backup system for non-critical functions within a timeframe consistent with mission latency requirements.	The non-critical functions are functions other than those listed as critical.	MSS	3.1.4.4 & 3.5.2.4.4
MOC1120	The MOC shall capable of restoring backup capabilities after a MOC critical system failure within 12 hours.		MSS	3.5.2.4.4 derived
MOC1130	The MOC shall provide the capability to backup appropriate files and recover the system from the backup.		MSS	3.5.1.8 derived
MOC1140	The MOC shall provide a web interface to authorized users for access to MOC data products.		MSS	3.5.3.5 3.5.1.2 derived
MOC1150	The MOC shall accommodate observatory telemetry that is compliant with the Consultative Committee for Space Data Systems (CCSDS) Packet Telemetry Recommendations as defined in the Series 100 Blue Books.	Telemetry will be compliant with AOS Version 2.	MSS	3.5.2.4.3.1

Req ID	Requirement	Comments	Source	Source ID
MOC1160	The MOC shall accommodate observatory commanding that is compliant with the CCSDS Telecommand recommendations as defined in the Series 200 Blue Books.	Commanding will follow COP-1 protocol.	MSS	3.4.1.5 derived
MOC1170	The MOC shall utilize the COP-1 protocol to verify correct receipt of commands on the spacecraft.		MSS	3.4.1.5 derived
MOC1180	The MOC shall contribute no more than 1% to the total Spacecraft Data Loss requirement allocated to the ground system.		MSS	3.5.2.4.4
MOC1190	The MOC shall provide the necessary personnel and facilities to support all pre-launch interface and system test activities.		MSS	3.5.1.6 derived
Interface				
MOC1200	The MOC shall provide the capability to interface with the ground station network for planning and conducting S/C contacts.		MSS	3.1.1.5.3, 3.5.3.1.1 & 3.5.3.1.2
MOC1220	The MOC shall provide the capability to interface with the SN for planning and conducting S/C contacts.		MSS	3.5.3.1.1 & 3.5.3.1.2
MOC1240	The MOC shall provide the capability to interface with the SSC for the exchange of mission planning and data products.		MSS	3.5.1.2 & 3.5.1.3 derived
MOC1250	The MOC shall have the capability to receive requests for retransmission of observatory data from the IOCs.			Derived
MOC1255	The MOC shall provide the capability to submit requests for retransmission of observatory data to the ground stations.			Derived

Req ID	Requirement	Comments	Source	Source ID
MOC1260	The MOC shall provide the capability to interface with the GBM IOC for the exchange of mission planning and data products.	The primary mission planning path is through the SSC.	MSS	3.5.1.2 & 3.5.1.3 derived
MOC1270	The MOC shall provide the capability to interface with the LAT IOC for the exchange of mission planning and data products.	The primary mission planning path is through the SSC.	MSS	3.5.1.2 & 3.5.1.3 derived
MOC1280	The MOC shall have the capability to interface with the S/C vendor facility for support of sustaining engineering functions.		MSS	3.5.2.2
MOC1290	The MOC shall exchange telemetry and command data with the GLAST S/C as specified in the GLAST *Spacecraft-MOC ICD*.		MSS	3.5.3.1.2 derived
Facility				
MOC1300	The MOC facility shall restrict physical access to allow entry to authorized personnel only		MSS	3.5.1.2 derived
MOC1310	The MOC facility shall provide console, analysis and meeting space for the FOT, S/C engineers and the instrument team engineers during Launch and Early Orbit (L&EO).			Derived
MOC1330	The MOC facility shall provide a voice communications system with the capability to connect to ground stations, Kennedy Space Center (KSC) launch site, the SN, the IOC's and the SSC.		MSS	3.5.1.8 & 3.5.1.11
MOC1340	The MOC facility shall provide UTC clock and countdown clock displays.		MSS	3.3.1.12 derived
MOC1350	The MOC facility shall provide a master time signal for the MOC systems.	e.g. NASA 36	MSS	3.3.1.12 derived
MOC1360	The MOC facility shall provide an uninterruptible power supply (UPS) to all the MOC systems.	This is to provide the opportunity to gracefully shutdown non-critical functions and allow backup power to be supplied.		Derived

Req ID	Requirement	Comments	Source	Source ID
MOC1370	The MOC facility shall provide the ability to access a backup power capability in the event of a utility power outage.	Current plans are to access diesel power in building 14.		Derived
MOC1380	The MOC facility shall provide black/white and color printers to generate reports, printouts, and plots as required.			Derived
MOC1390	The MOC facility shall provide the ability to support R/T operations, mission planning, data processing, mission analysis and special operations (e.g. L&EO).		MSS	3.5.1.8 derived
Documentation				
MOC1500	The MOC shall maintain electronic documentation of operating procedures to specify the tasks to be performed for routine operational and contingency activities.			Derived
MOC1510	The MOC shall maintain configuration control of the electronic documentation.			Derived
MOC1520	The MOC shall restrict access to the electronic documentation to authorized operations personnel.		MSS	3.5.1.2
Real-time Operations				
Telemetry				
MOC2100	The MOC shall receive, process and monitor telemetry data from the GLAST observatory.		MSS	3.5.1.3
MOC2110	The MOC shall ingest and store all CCSDS transfer frames received.		MSS	3.5.2.11 derived
MOC2120	The MOC shall receive R/T h/k telemetry from the ground station at a maximum rate of 32kbps.		MSS	3.5.3.1.2 derived

Req ID	Requirement	Comments	Source	Source ID
MOC2130	The MOC shall provide the capability to receive and process R/T telemetry from TDRSS at a maximum rate of 8kbps.		MSS	3.5.3.1.2 derived
MOC2140	The MOC shall provide the capability to receive and process status data from ground stations.		MSS	3.1.1.5.3
MOC2150	The MOC shall provide the capability to receive and process status data from the SN.		MSS	3.3.5.4 Observatory constraint extended to the MOC-derived
MOC2160	The MOC shall receive and forward Burst alerts from the ground stations and TDRSS to the GCN.		MSS	3.1.4.1.3 & 3.5.3.3 derived
MOC2170	The MOC shall provide the capability to process ground station R/T status packets.	This will include items such as include the number of commands received/uplinked, Virtual Channel (VC) counts, and quality statistics	MSS	3.5.2.4.1
MOC2180	The MOC shall receive recorded observatory h/k and science data post pass from the ground stations.		MSS	3.1.1.5.3, 3.1.4.4.2 & 3.5.2.4.3.1
MOC2190	The MOC shall provide the capability to receive and process S/C and instrument on-board processor memory dump and table dump data.	Provided to S/C vendor and the IOC's for further processing.	MSS	3.5.2.4.3.1
MOC2200	The MOC shall receive and process observatory event and telecommand logs.	This will allow the FOT to view interpreted log reports for troubleshooting.	MSS	3.5.2.2 & 3.5.2.2.1
MOC2210	The MOC shall flag questionable quality data based on information received from the ground stations and the SN.		MSS	3.5.2.4.1

Req ID	Requirement	Comments	Source	Source ID
MOC2220	The MOC shall provide transfer frame processing statistics on each VC and on the aggregate.	This will include items such as the total number of frames for each of: received, good frames, sequence errors, and Reed-Solomon decoding errors.	MSS	3.5.2.4.1
MOC2230	The MOC shall archive all incoming frame telemetry data for the life of the mission.		MSS	3.5.2.11
MOC2240	The MOC shall have the capability to replay, process and display recorded h/k telemetry data at twice the R/T rate.			Derived
MOC2250	The MOC shall extract parameter data from the observatory h/k packets, and perform the necessary conversions per the T&C database.	Telemetry processing includes providing data extraction, state conversions and Engineering Unit (EU) conversions.		Derived
MOC2260	The MOC shall provide the capability to transmit real-time housekeeping data to the LIOC.		MSS	3.5.1.3 Derived
MOC2270	The MOC shall transmit recorded Level 0 data to the GIOC and LIOC.		MSS	3.5.1.3 Derived
Limits				
MOC2300	The MOC system shall automatically monitor R/T and playback telemetry data for limit violations as defined in the PDB.	Limit checking will be performed on both analog and discrete telemetry parameters. The MOC system will not perform limit checking on questionable quality data.		Derived
Sequential Prints				
MOC2400	The MOC shall provide the capability to extract specific parameter data and create a sequential print ASCII formatted file.			Derived
Database				
MOC2500	The MOC shall provide the capability to ingest and verify the observatory telemetry & command (T&C) database provided by the S/C vendor.	Verification includes syntax level checking of database, Ex. Command mnemonic created expected bit sequence.		Derived

Req ID	Requirement	Comments	Source	Source ID
MOC2510	The MOC shall construct a Project Database (PDB) that consists of the observatory T&C database and other ancillary data required for flight operations.			Derived
MOC2520	The MOC shall provide the capability to maintain configuration control of the PDB, command PROCs, display page definitions and configuration monitor definitions.			Derived
TDRSS Messages				
MOC2600	The MOC shall receive unscheduled TDRSS messages containing S/C and instrument alarm messages through the SN/Demand Access System (DAS).		MSS	3.5.3.1.2
MOC2605	The MOC shall receive unscheduled TDRSS messages containing SN station status whenever the SN/DAS is being actively used.		MSS	3.5.3.1.2 Derived
MOC2610	The MOC shall receive burst alerts from the S/C via the SN/DAS.		MSS	3.5.3.1.2
Burst Alert Handling				
MOC2700	The MOC shall transmit burst alerts to the GCN, the GIOC and GBM Burst Alert Processor (BAP) received from ground stations and the SN.		MSS	3.5.3.3 Derived
MOC2710	The MOC shall transmit burst alerts to the GCN within 0.5 seconds of their receipt for at least 80% of the burst alerts.	Performance measured from receipt at the MOC to initiation of the transfer.	MSS	3.1.4.1.3
Display Pages				

Req ID	Requirement	Comments	Source	Source ID
MOC2800	The MOC shall provide the capability to display processed telemetry data and their associated quality and status attributes in R/T display pages.			Derived
MOC2810	The MOC shall provide the capability to print telemetry snapshots of any display page.			Derived
MOC2820	The MOC shall provide the capability to display telemetry data plots via screen plots.			Derived
Events				
MOC2900	The MOC shall generate and display time-tagged event messages indicating all command activity, telemetry processing status, limit violations, configuration changes, and all error and warning conditions.			Derived
MOC2910	The MOC shall provide the capability to log all event messages to a history file in the chronological order in which they are received.		MSS	3.5.2.11
MOC2920	The MOC shall provide the capability to retrieve and display logged system event messages.		MSS	3.5.2.11
Command				
MOC3000	The MOC shall have the capability to send commands to the observatory using ground stations, and the SN/TDRSS.	This includes R/T commands, command loads, software loads and table loads.	MSS	3.5.3.1.1
MOC3010	The MOC shall be capable of transmitting commands to the ground network (GN) at a rate of 2kbps.		MSS	3.5.3.1.2 derived
MOC3020	The MOC shall be capable of transmitting commands to the SN/TDRSS at rates of 250bps and 4 kbps.		MSS	3.5.3.1.2 derived

Req ID	Requirement	Comments	Source	Source ID
MOC3030	The MOC shall be capable of generating R/T commands based on a combination of the definitions in the PDB and user input.			Derived
MOC3040	The MOC shall be capable of generating stored command loads, including absolute and relative time sequence loads (ATS and RTS).		MSS	3.3.2.2.7 & 3.3.2.3.10 derived
MOC3050	The MOC shall be capable of generating software memory loads for uplink to the S/C from flight software images provided by the S/C and instrument Flight Software (FSW) maintenance facilities.		MSS	3.5.2.2.2
MOC3060	The MOC shall maintain a ground reference image for S/C memory.			Derived
MOC3070	The MOC shall provide protection against the unintentional issue of a critical command, as indicated in the PDB by requiring the operator to explicitly allow the command to be sent.			Derived
MOC3080	The MOC shall archive all executed commands for the life of the mission.		MSS	3.5.2.11 derived
MOC3090	The MOC shall provide a user interface language for system configuration and control, telemetry monitoring and commanding.			Derived
MOC3100	The MOC shall provide the capability to bypass COP-1 commanding.		MSS	3.4.1.5 derived
Clock correlation				
MOC3140	The MOC shall provide capability to monitor accuracy and performance of the S/C clock.	The ability to support this assumes that sufficient information is available in h/k telemetry.	MSS	3.5.3.2 GPS derived

Req ID	Requirement	Comments	Source	Source ID
Mission Planning & Scheduling				
MOC4000	The MOC shall schedule all activities for the GLAST observatory except those autonomously executed by the S/C.	The primary mission planning tasks are: A. Integrated Observatory Timeline Generation. B. Ground Station Scheduling. C. TDRSS Scheduling. D. ATS and RTS Load Creation and Management.	MSS	3.5.2.2 derived
MOC4010	The MOC shall provide the capability to schedule all s/c and instrument engineering events within the constraints of the s/c and instruments.	This applies to non-science related activities needed for observatory h/k.	MSS	3.5.2.2 derived
MOC4020	The MOC shall provide the capability to schedule all contacts with the S/C for command uplink and telemetry downlink.	This applies to the SN/TDRSS and ground stations.	MSS	3.5.3.1.1 & 3.5.3.1.2 derived
MOC4030	The MOC shall accept flight software load requests from the s/c vendor and instrument teams including the FSW load and time/conditions to uplink.		MSS	3.5.2.2.2 derived
MOC4040	The MOC shall provide TDRSS handover and position information to the S/C.	This provides information to communicate with TDRSS.	MSS	3.5.2.2 derived
MOC4050	The MOC shall provide the capability to manage the Solid State Recorder (SSR) to include dumping and re-dumping of science and engineering data.		MSS	3.5.2.2 derived
Integrated Observatory Timeline				
MOC4100	The MOC shall provide the capability to generate an Integrated Observatory Timeline.	The Integrated Observatory Timeline is based on inputs from the SSC, ground stations, the SN, and flight operations. It contains a list of planned activities/events.		Derived

Req ID	Requirement	Comments	Source	Source ID
MOC4110	The MOC shall use UTC time for planning and generation of commands.		MSS	3.3.1.8 derived
MOC4120	The MOC shall produce ATS loads based on the Integrated Observatory Timeline.			Derived
MOC4130	The MOC shall provide the capability to ingest and integrate the science timelines created by the SSC.	These timelines are sequences of onboard activities.	MSS	3.5.2.3 derived
MOC4140	The MOC shall provide the Integrated Observatory Timeline to the SSC.			Derived
MOC4150	The MOC shall provide the capability to re-plan a 24-hour (TBR) portion of the Integrated Observatory Timeline within 2 hours(TBR).			Derived
MOC4160	The MOC shall provide the capability to update the on-board ATS command load based on late schedule change requests.	Here the users (IOC's, SSC, MOC) have determined that that the planned observations already loaded on the spacecraft need to be changed.		Derived
MOC4170	The MOC shall provide the capability to ingest and integrate the ground station contact schedules.		MSS	3.5.3.1.1 derived
MOC4180	The MOC shall provide the capability to ingest and integrate the TDRSS contact schedules.		MSS	3.5.3.1.1 derived
MOC4190	The MOC shall provide the capability to generate and manage command constraint definitions.			Derived
MOC4200	The MOC shall verify all command loads against constraints prior to uplink to the S/C.			Derived
Flight Dynamics				
MOC4300	The MOC shall provide the capability to generate orbital products using s/c provided orbit information and NORAD provided Two Line Elements (TLE).		MSS	3.5.3.2

Req ID	Requirement	Comments	Source	Source ID
MOC4310	The MOC shall provide the capability to receive and process orbit solutions from the Flight Dynamics Facility.		MSS	3.5.3.2
MOC4320	The MOC shall provide the capability to perform orbit propagation.		MSS	3.5.3.2
MOC4330	The MOC shall ensure 1 second accuracy for a minimum of 3 days for Absolute Time Commands tied to orbital events.	This drives the accuracy of the orbit propagation function in the MOC, and thus the accuracy of stored command execution times.	MSS	3.5.3.2
MOC4340	The MOC shall deliver orbit data products covering TBD hours to the SSC and the IOC's every TBD days within TBD hours	This includes predictive and/or definitive.	MSS	3.5.3.2
MOC4350	The MOC shall maintain a log of orbit solutions for the duration of the mission		MSS	3.5.3.2
MOC4360	The MOC shall provide the capability to uplink orbit ephemeris data to the observatory.	This capability is needed if the onboard GPS system is not functioning properly.	MSS	3.5.3.2
TDRSS Scheduling				
MOC4400	The MOC shall provide the capability to schedule the SN services.	This applies to scheduling TDRSS/DAS, WDISC MA and WDISC SSA services via the SpaceNetwork Web Services Interface (SWSI).	MSS	3.5.3.1.1
MOC4410	The MOC shall provide s/c orbit information to the SN for contact acquisition.		MSS	3.5.3.2
Ground Station Scheduling				
MOC4500	The MOC shall provide the capability to schedule contact with ground stations.		MSS	3.5.3.1.1 derived
MOC4510	The MOC shall provide orbital elements to the ground stations for contact acquisition.		MSS	3.5.3.2 derived
Target Of Opportunity (ToO)				

Req ID	Requirement	Comments	Source	Source ID
MOC4600	The MOC shall provide the capability to accept Target of Opportunity (ToO) observation orders from the SSC.		MSS	3.5.2.7.2 derived
MOC4620	The MOC shall provide an automatic acknowledgement of the receipt of a ToO order to the SSC within 10 minutes.		MSS	3.5.2.7.2 derived
MOC4630	The MOC shall provide the capability to send the SSC a message that specifies the disposition of the ToO order.		MSS	3.5.2.7.2 derived
MOC4640	The MOC system shall provide the capability to generate ToO commands, schedule TDRSS forward link service, and be prepared to transmit the commands within 4 hours of receipt of the ToO order from the SSC.	Does not include the time required by the SSC for ToO handling nor the time for the SN to make the forward link service available. Latency applies only if no problems are encountered that require operator intervention. Otherwise the ToO will be handled on a best effort basis.	MSS	3.5.2.7.2
MOC4650	The MOC shall maintain a log for the duration of the mission of all ToO orders, and their dispositions.		MSS	3.5.2.11 derived
Autonomous Re-pointing Support (AR)				
MOC4660	The MOC shall maintain a log for the duration of the mission of all ARs.		MSS	3.3.2.4.1 Derived
MOC4670	The MOC shall notify appropriate science and operations personnel in the event of an AR.			Derived
Offline Analysis				
MOC4700	The MOC shall monitor the h/k telemetry data for S/C and instrument health and safety.		MSS	3.5.2.2 & 3.5.2.2.1 derived

Req ID	Requirement	Comments	Source	Source ID
MOC4710	The MOC shall provide the capability to automatically process recorded observatory h/k data when received from the ground stations.		MSS	3.5.1.3
MOC4720	The MOC shall provide the capability to create pass summaries that describe the results of each S/C contact.	This includes selected mnemonics, procedures executed, S/C events, system events, commands sent, and limit and configuration monitor violations.		Derived
MOC4730	The MOC shall provide the capability to replay and process recorded housekeeping data.	This provides the ability to replay previous data through the real-time system.		Derived
Configuration Monitoring				
MOC4800	The MOC shall provide the capability to monitor the configuration of the observatory and detect deviations from expected states.			3.5.2.2 & 3.5.2.2.1 derived
As-flown timeline				
MOC4840	The MOC shall produce an as-flown timeline that reflects the observations that were actually executed on the observatory.	The as-flown timeline will be derived from the observatory housekeeping telemetry. This should reflect ToOs and auto repoints.		Derived
MOC4850	The MOC shall provide the as-flown timeline covering a 24-hour period to the SSC and the IOC's within 7 days.			Derived
Emergency Response				
MOC4900	The MOC shall provide the capability to monitor autonomous S/C pass operations and ground systems without the presence of MOC personnel.		MSS	3.5.1.3 derived
MOC4910	The MOC shall provide the capability to automatically log an anomaly report for system-detected events meeting pre-defined criteria.			Derived
MOC4920	The MOC shall provide the capability to enter and manage S/C and ground system anomaly reports.			Derived

Req ID	Requirement	Comments	Source	Source ID
MOC4930	The MOC shall provide the capability to maintain for the life of the mission the database of all S/C and ground anomalies for both pre-launch and post-launch operations.		MSS	3.5.2.11 derived
MOC4940	The MOC shall provide the capability to automatically send notifications to the FOT to alert them of important events in the MOC or on the S/C within 60 seconds of detecting the event.	Notifications can be methods such as alphanumeric pages and emails.	MSS	3.5.1.3 derived
MOC4950	The MOC shall maintain a log of all user notificaitons sent and acknowledgements received.		MSS	3.5.2.11 derived
Timeline Monitoring				
MOC5000	The MOC shall examine observatory data from each ground station contact to determine if any unexpected deviations from the pre-planned timeline have occurred.			3.5.2.2 & 3.5.2.2.1 derived
TDRSS Message Monitoring				
MOC5100	The MOC shall monitor GRB alert messages from TDRSS and initiate a page to appropriate on-call personnel for alerts meeting pre-defined criteria.		MSS	3.1.2.4 derived
MOC5120	The MOC shall monitor emergency alert messages received from TDRSS and initiate a page to appropriate on-call personnel when the MOC is not staffed.		MSS	3.4.2.2.1 derived
MOC5130	The MOC shall monitor h/k telemetry messages from TDRSS and initiate a page to appropriate on-call personnel when the MOC is not staffed for any anomalies or limit violations.			3.5.2.2 & 3.5.2.2.1 derived
Trend Analysis				

Req ID	Requirement	Comments	Source	Source ID
MOC5200	The MOC shall provide the capability to perform data trending and analysis of observatory h/k data.			3.5.2.2 derived
MOC5210	The MOC shall provide the capability to generate graphical and numeric plots and reports of historical observatory h/k data.			3.5.2.2 derived
MOC5220	The MOC shall maintain trends of key parameters for the life of the mission.		MSS	3.5.2.11 derived
MOC5230	The MOC shall provide the capability to perform statistical analysis of selected parameters over selected time-spans.	Ex. Daily maximum, minimum, mean and standard deviation statistics		3.5.2.2 derived
MOC5240	The MOC shall provide access to trending and analysis capabilities via the Internet for analysis by remote users.		MSS	3.5.3.5 derived
MOC5250	The MOC shall provide the capability to view and print reports, and save them to a file			Derived
MOC5260	The MOC shall provide the capability to export ASCII formatted data containing observatory h/k and other operations related data.	Provides ability for external analysis applications to access observatory data (e.g., Excel tool).	MSS	3.5.3.5 derived
Ground System Monitoring				
MOC5300	The MOC shall monitor the MOC systems to determine any network and system process failures affecting processing functions.			Derived
MOC5310	The MOC shall monitor critical external interfaces to determine their availability for support.	Will be limited by the availability of status information from the external systems.	MSS	3.5.3 derived
MOC5320	The MOC shall monitor for MOC network security violations and initiate paging to the appropriate personnel.		MSS	3.5.1.2 derived
Data Capture & Processing				

Req ID	Requirement	Comments	Source	Source ID
MOC6000	The MOC shall perform Level 0 processing using observatory data files received from the ground stations and TDRSS.		MSS	3.5.1.3 derived
MOC6010	The MOC shall generate Level 0 files for each contact that contain error free, time ordered non-duplicate series of packets.	Each file may have one or multiple application identifications (APIDs). MOC will not merge dump files from multiple contacts.	MSS	3.5.1.3 derived
MOC6020	The MOC shall automatically monitor the delivery of telemetry data from ground stations and alert the operations staff when the data is not received in the required time.		MSS	3.5.1.3 derived
MOC6030	The MOC shall automatically assess the quality of each file received from a ground station and page appropriate personnel if problems are detected that require operator intervention.			3.5.1.3 derived
MOC6040	The MOC shall maintain a record of the quality and completeness of the telemetry for the duration of the mission.		MSS	3.5.2.11 derived
MOC6050	The MOC shall provide the capability to distinguish between test data and operational data.	Dependent upon having appropriate flags set in the data.		Derived
MOC6060	The MOC shall generate meta-data for each Level 0 file that describes the characteristics of the file.		MSS	3.5.1.3 derived
MOC6070	The MOC shall generate the Level 0 data files within 4 hours of receiving the dump files from the ground station.	Applies only if no problems are encountered that require operator intervention. Otherwise the data will be delivered on a best effort basis.	MSS	3.1.4.4.2 derived
MOC6180	The MOC shall provide the capability to retrieve and process archived observatory data.		MSS	3.5.2.11 derived

Req ID	Requirement	Comments	Source	Source ID
MOC6190	The MOC shall provide the capability to copy products to removable physical media.			Derived
MOC6200	The MOC shall archive the Level 0 data files a miminum of seven days.	This provides the capability to retransmit the files to the SSC or IOCs as necessary.	MSS	3.5.2.11 derived

3.6 LAT IOC Requirements

This section will be provided in a later revision to this document.

3.7 GBM IOC Requirements

This section will be provided in a later revision to this document.

3.8 SSC Requirements

This section will be provided in a later revision to this document.

3.9 GCN Requirements

This section will be provided in a later revision to this document.

3.10 HEASARC Requirements

This section will be provided in a later revision to this document.